V. Summary of Claimed Subject Matter

Claim 42 is directed to a method of forming a rounded corner 216 (Figure 6; page 16, line 24; page 5, line 28) of a trench of a workpiece in the form of silicon substrate 202 (Figure 5; page 15, line 2) in vacuum plasma chamber 40 (Figure 1; page 7, lines 3 and 4; page 1, lines 2-5). A gas species, particularly a mixture of HBr/O2 (page 16, line 29-page 17, line 1) that is supplied to chamber 40, is converted (page 7, line 29-page 8, line 3) into an etchant plasma that is continuously applied to workpiece 202 while rounded corner 216 is being formed (page 16, line 23-page 17, line 1). While rounded corner 206 is being formed, the power applied to the etchant plasma is gradually changed (page 17, lines 1-4). The gradual changes are such that the power applied to the etchant while rounded corner 206 is being formed does not remain constant for durations in excess of one second (page 6, lines 9 and 10; page 13, lines 13-16). The inventors have found that steps lasting longer than about one second do not have adequate temporal resolution to achieve the desired workpiece shapes (page 6, lines 9 and 10). While rounded corner 206 is being formed, the mixture of HBr/O2 constantly flows into chamber 40 (page 16, line 29-page 17, Line 1) so the flow rate of the gas species into chamber 40 and the species flowing into chamber 40 are maintained constant while the rounded corner is being formed.

Independent claim 47 is concerned with a method of etching workpiece 202 (Figure 5; page 15, line 2) in vacuum plasma processor chamber 40 (Figure 1; page 7, lines 3 and 4). A gas species in the form of HBr/O2 (page 16, line 29-page 17, line 1) is converted into an AC etchant plasma (page 1, line 4; page 15, line 16 and 26) that is applied to workpiece 202 while a desired shape (page 6, line 14), in the form of rounded corner 216 (Figure 6) of workpiece 202, is being formed. The AC etchant plasma is always the dominant material applied to the workpiece while the desired shape is being formed (page 5, lines 26-28; claim 8, page 19 of the application as filed; page 16, line 23-page 17, line 2; page 17, lines 4-6). Vacuum chamber 40 is subject to operating at different pressures

while workpiece 202 is being processed (page 9, lines 3-5), and the gas species can flow at different flow rates into chamber 40 while workpiece 202 is being processed (page 8, lines 23-25). The amount of AC power supplied to the plasma during etching of workpiece 202 to form the desired shape rounded corner 216 gradually changes on a pre-programmed basis (page 10, lines 7-15; page 11, lines 12-16; page 11, line 23-page 12, line 2; page 12, line 25-page 13, line 5; page 14, lines 7-9). A gradual transition in the shape of material that has the desired rounded corner shape in workpiece 202 being processed occurs in response to the gradual power change (page 16, line 21-page 17, line 2). The gradual power change occurs during the gradual transition in the shape of the material that has the rounded corner desired shape (page 16, line 21-page 17, line 2).

Independent claim 59 is directed to a memory 24 (Figure 1) storing a computer program for controlling a computer for controlling etching of workpiece 202 in vacuum plasma processor chamber 40 (page 7, lines 15-20; page 12, lines 8, 9 and 25-28). Claim 59 indicates the memory causes the computer to control etching of workpiece 202 to perform the same steps as defined by claim 47.

Claim 40, dependent on claim 42, indicates the gradual change includes steps having power changes no greater than several watts, indicated as being 15 watts in the specification (page 6, line 6; page 13, line 13).

Claims 41 and 55, respectively dependent on claims 40 and 54, in turn dependent on claim 49 which is ultimately dependent on claim 47, state the power steps are a few milliwatts, indicated as being 6.667 milliwatts in the specification, and remain at a constant power for about 1 millisecond (page 17, line 4).

Claims 46 and 56, respectively dependent on claims 40 and 54, indicate an electric source, in the form of variable gain power amplifier 132 of circuit 14 that applies RF to electrode 56 (Figure 1; page 11, lines 12-16; page 12, lines 18-24) applies the gradually changing power to the etchant plasma in steps having a maximum change of less than 5% of the source maximum output power (page 13, lines 10 and 11; page 6, lines 4 and 5). The inventors found steps having power changes greater than about 5% of the maximum output power are too steep to provide the desired control over the plasma to achieve the desired workpiece shapes (page 6, lines 7-9).

Claims 48 and 60, respectively dependent on claims 47 and 59, indicate the etchant plasma is continuously applied to workpiece 202 while the desired rounded corner shape 216 is being formed (page 16, line 29-page 17, line 1).

Claims 49 and 61, respectively dependent on claims 48 and 60, indicate the gradual power change occurs while no change is made in the species, pressure or flow rate of the gas species that is converted into the AC etchant plasma applied to workpiece 202 to form the desired, rounded corner shape 216 (page 16, lines 28 and 29).

Claims 50 and 62, respectively dependent on claims 48 and 60, indicate the desired shape is a curved surface, which in the specific embodiment is rounded corner 216 (Figure 6; page 16, line 24). The rounded corner is specifically set forth in claims 51 and 63, respectively dependent on claims 50 and 62 (page 16, lines 21-25). Claims 52 and 64, respectively dependent on claims 51 and 63, indicate rounded corner 216 is at an intersection of a wall and base 214 of the trench illustrated in Figure 6.

Claim 53 indicates the curved surface of claim 50 is rounded corner 216 that is at an intersection of a wall and a surface, in the form of the base 214 that intersects the wall, wherein the surface 214 extends generally at a right angle to the wall (Figure 6).

Claim 54 states the gradual change of claim 49 includes steps having power changes no greater than about several watts (indicated as 15 watts at page 6, line 6 and page 13, line 13), wherein the power remains constant at a wattage for no more than about one second (page 6, lines 9 and 10; page 6, line 6; page 17, line 4).

Claims 57 and 65, respectively dependent on claims 48 and 62, indicate the gradual power change includes steps having power changes in the range of a few milliwatts to several watts and durations in the range of about 1 millisecond to no more than one second (page 6, lines 4-10).

Claims 58 and 66, respectively dependent on claims 50 and 60, require the gradual change to include steps having power changes no greater than about several watts (specifically 15 watts), and the power to remain at a constant wattage for no more than about second (page 6, lines 4-10).

IX. Evidence Appendix

1. The Declaration of Andrew Bailey, Ph.D., including Exhibit 1, submitted to the Patent and Trademark Office June 9, 2006; acknowledged and presumably entered into the record on page 7 of the September 18, 2006, Office Action;

2. The Declaration of Andrew Bailey, Ph.D., submitted to the Patent and Trademark Office June 24, 2007; acknowledged and presumably entered into the record on page 8 of the August 23, 2007, final rejection;

3. The Declaration of Thomas Kamp, submitted to the Patent and Trademark Office June 24, 2007; acknowledged and presumably entered into the record on page 8 of the August 23, 2007, final rejection.

Evidence Document 1,

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Docket No.: 2328-053 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:
	:
Tuquiang NI et al.	: Confirmation No. 5171
	:
U.S. Patent Application No. 09/821,753	: Group Art Unit: 1763
	:
Filed: March 30, 2001	: Examiner: Luz L. ALEJANDRO

For: PLASMA PROCESSING METHOD AND APPARATUS WITH CONTROL OF PLASMA EXCITATION POWER

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF ANDREW D. BAILEY III, Ph.D.

I, Andrew D. Bailey III, Ph.D., hereby declare as follows:

1. Exhibit 1 is an accurate statement of my education, work experience, honors, publications, presentations and abstracts and issued United States Patents. As part of my work experience, I have worked closely with those of ordinary skill in the art relating to plasma processing of work pieces and have supervised many persons of ordinary skill in the art in the plasma processing of work pieces. As a result of my work experience, I am knowledgeable of those of ordinary skill in the art in the plasma processing of work pieces. I am also regarded by my peers as an expert in the technology relating to plasma processing of work pieces. Many of the publications listed in Exhibit 1 are publications in refereed journals, and as such, were subject to peer review prior to publication.

2. I have carefully read the referenced application as filed, the claims presently pending in the referenced application, the Office Action of March 9, 2006, and the Bhardwaj et al. reference, USP 6,051,503, primarily relied on in the Office Action.

3. My review of the referenced application, as originally filed, finds support for the requirement of claims 1 and 17 for "the AC etchant plasma always being the dominant material applied to the work piece while the feature is being formed."

(a) Page 5, lines 26-28 and claim 8, page 19 indicate that in the preferred embodiment, a gas species is ionized into a plasma that etches the material and that the preprogrammed gradual power change and the species are such that the material is shaped so a rounded corner is formed in the material as a result of the etching. This statement enables one of ordinary skill in the art to understand that the feature is the rounded corner. One of ordinary skill in the art would understand from the statement that an AC etchant plasma is always the dominant material applied to the work piece while the rounded corner is being formed.

(b) Page 6, lines 1 and 2 and claims 9 and 10, on page 19 of the application as filed, state that in one specific embodiment, the etching forms a trench wall including the rounded corner, which in one embodiment is at an intersection of a wall and a base of a trench. One of ordinary skill in the art would understand, from this statement, that an etchant is a dominant material that forms a trench wall including a rounded corner, which one of ordinary skill in the art would equate with a feature, particularly since page 6, lines 1-2 and claims 9 and 10 indicate the rounded corner is at an intersection of a wall and a base of a trench.

(c) Page 6, lines 26-29, of the application as filed indicates Figure 5 is a schematic diagram of a cross section of an illustrative semiconductor wafer prior to etching and Figure 6 is a schematic diagram of the wafer illustrated in Figure 5 after it has been etched in accordance with a specific embodiment of the invention. Such a statement would lead one of ordinary skill in the art to understand that the changes that occurred in transforming the structure of Figure 5 into the structure of Figure 6 was caused by etching being a dominant material applied to the wafer.

(d) Page 8, lines 20-23, in paragraph 30 of the application as filed, indicates there usually are several gas sources of different species, e.g., etchants, such as SF_6, CH_4, C_{12}

and HBr, dilutants such as Ar or He and O_2 as a passivation gas. One of ordinary skill in the art would interpret this to mean that a feature could be formed exclusively from the etchant gas which would be a dominant gas to form the material, or as a combination of the etchant gas, the dilutant gas and/or the oxygen passivation gas. Based on the other statements in the application as filed about etching occurring to form the trench walls and rounded corner, one of ordinary skill in the art would know that the etchant gases referred to at page 8, lines 20-23, were the dominant gases in the etching operations.

(e) Page 9, lines 16 and 17 indicates that an end point is detected of the process (either etching or deposition) that plasma 50 is performing on work piece 54. This statement would be interpreted by those of ordinary skill in the art as detecting the end of an etching process dominated by an etchant gas or the end of a deposition step dominated by a deposition gas, such as oxygen serving as a passivation gas.

(f) Page 14, line 28-page 15, line 2 indicates Figures 5 and 6 are respectively schematic drawings of an illustrative semiconductor structure prior to and subsequent to etching operations in accordance with one embodiment of the present invention. Such a statement would be interpreted by one of ordinary skill in the art as a transformation occurring from the structure of Figure 5 to the structure of Figure 6 as a result of an etchant gas being the dominant material applied to the semiconductor structure.

(g) Page 15, line 8-page 16, line 20 refers only to etching of the structure of Figure 5 to get slightly above the trench final base 214, as illustrated in Figure 6. Page 16, lines 20-23 indicate the final etch operation of silicon substrate 202 between point 212 and base 214 is performed in such a manner as to achieve rounded edges 216 between point 212 and base 214. This statement indicates to one or ordinary skill in the art that an etching operation, using an etchant gas as the dominant material, results in the production of rounded edge 216.

(h) Page 16, line 26-page 17, line 1 states microprocessor 201 has a memory system that performs the final etch operation for 15 seconds. During the 15 second final etch operation a suitable mixture of HBr/O_2 constantly flows from source 68 into

chamber 40. One of ordinary skill in the art would interpret such a statement to mean that the etchant HBr is dominant over the O_2 passivation gas because the memory system is stated to perform the final etch operation.

(i) Page 17, lines 4 and 5 indicates that after base 214 has been reached, the etchant gases are purged from the chamber. Such a statement would lead one of ordinary skill in the art to assume that the etchant gases were the dominant gases applied during the formation of the features involved in etching the structure of Figure 5 into the structure of Figure 6.

4. I do not agree with the statement in the Office Action that Bhardwaj et al. discloses converting a gas species into an AC etchant plasma that is either the dominant material or the only material that is continuously applied to a work piece while a feature of the work piece is being formed. The Office Action erroneously states that a portion of the side wall of a trench can be considered as an exemplary feature.

(a) Each of independent claims 1, 29, 30 and 31 of Bhardwaj et al. is concerned with a method of etching a feature in a semiconductor substrate. To form the feature, the substrate is subjected to a cyclical process including plural successive process cycles. Each of the successive process cycles includes a first process of reactive ion etching and a second process of depositing a passivation layer by chemical vapor deposition.. Column 1, lines 4-13, of Bhardwaj et al. indicates that one possible feature is a trench wall, not a portion of the side wall of a trench.

(b) Based on the foregoing, it is clear to me, as an expert in the technology,.that Bhardwaj et al. does not disclose converting a gas species into an AC etchant plasma that is either the dominant or only material that is continuously applied to a work piece while a feature of the work piece is being formed. The entire thrust of the Bhardwaj et al. patent is to form a feature by alternately etching and depositing materials, as indicated, for example, by the waveforms of Figure 7, wherein the first, fourth and seventh columns are associated with etching, the second and fifth columns are associated with deposition, and the third and sixth columns are associated with pump out of gases. Figure 7 indicates

that during the etch steps, the coil power and the bias power remain constant and that the coil and bias power also remain constant during the etch steps. The waveforms of Figure 9(i) and 9(ii) indicate that bias power changes abruptly between the etch and deposition steps. The RF bias is high during the deposition steps when pressure is low, and is low during the etch steps, when pressure is high. Column 9, lines 47-51 indicates the bias changes from low to high as the cycle changes from deposition as etch, respectively, in synchronism with pressure changes from low to high. These alternate etch and deposition steps occur during etching of a feature, particularly a side wall, as discussed in column 1, lines 4-13 and as set forth in the independent claims.

(c) The discussion in Bhardwaj et al., column 8, line 27-column 9, line 34 indicates the importance Bhardwaj et al. ascribed to the alternate etching and deposition steps to form a feature. This portion of Bhardwaj et al. indicates the problems associated with the prior art, as represented by Figure 3, in forming a silicon trench only by etching. The paragraph bridging columns 8 and 9 is particularly relevant because it discusses the importance of the passivation, i.e., deposition, step.

(d) Based on the foregoing, Bhardwaj et al. does not form a feature of a work piece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the work piece while the feature is being formed, wherein the amount of AC power applied to the plasma during etching of the work piece to form the feature gradually changes and a gradual transition in the shape of the material in the work piece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material. While Bhardwaj et al. discloses gradual power change, the gradual power change is always associated with alternate application of etchant gas and deposition gas to the work piece during formation of the feature.

(e) In addition, Bhardwaj et al. does not form a feature of a work piece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the work piece, wherein the amount of AC power applied to the plasma during etching of the work piece gradually changes and a gradual transition in the shape of the

material in the work piece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine, or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

DATED this 5 day of June, 2006, at Fremont CA.

Andrew D. Bailey III, Ph.D.

EXHIBIT 1 – ANDREW D. BAILEY III, PH.D. DECLARATION

Lam Research Corporation
4650 Cushing Parkway CA-3
Fremont, CA 94538-6470
(510) 572 - 2200
andrew.bailey@lamrc.com

5167 Northway Road
Pleasanton, CA94566
(925) 461 - 8642

Education

Ph.D. Applied Physics 2/93
Experimental Plasma Physics
California Institute of Technology, Pasadena
Thesis Research: Used planar laser induced fluorescence to measure drift wave ion velocity field in a tokamak plasma and addressed relationship between stochastic particle trajectories and velocity distribution functions.
Advisors: Dr. Paul M. Bellan with Dr. Raul A. Stern (U. of Col. - Boulder)
B.S. Applied Mathematics, Engineering and Physics with Honors 5/87
University of Wisconsin - Madison GPA 3.9/4.0 Phi Beta Kappa

Experience

Technical Director 8/00 to present
Process Technology, New Product Development
Lam Research Corporation,
Fremont, CA

Responsible for managing the Plasma Process Technology engineering group for a number of Lam's emerging plasma processing products including hardware and applications on advanced plasma processing materials and integration flows internally, with industry partners and customers, e.g., 300mm Cu dual damascene, porous low-dielectric constant material, SiLK, organosilicate glass (OSG) etching, hi-dielectric constant material gate applications, magnetic random access memory (MRAM). Sponsor research activities in array multidisciplinary areas to support advanced capabilities: multivariate data analysis, university programs, rf technology and design.

Also responsible for process development on dual frequency confined (DFC) technology used in Lam 2300 Exelan 200/300mm plasma processors sold to leading semiconductor companies worldwide.

Program Manager New Product Dev. 2/98 to 8/00
Lam Research, Fremont, CA
Built group of 8 process engineers working on range of new products and programs: ADP, patents, novel documentation strategies, dielectric etch, low-dielectric, Joint Product Development Programs 300mm dual damascene

Director Process Development 9/97 to 2/98
Trikon Technologies, Chatsworth, CA
Responsible for all demonstration activity, eleven etch tools (21 modules), lab, supervised 14 engineering personnel during turbulent corporate period.

300mm Etch Program Manager 8/97 to 2/98
Trikon Technologies, Chatsworth, CA
Plan Trikon's 300mm etch program. Responsible for product development, engineering, process transfer, marketing, Supervise development team and form engineering team to design 300mm module. Work with outside suppliers of critical components. Manage group of people including a Ph.D., engineer personnel and those involved in planning and marketing.

MØRI Metal Etch Product Manager 1/97 to 7/97
Trikon Technologies, Chatsworth, CA (merger PMT and Electrotech)
Supervised 5 people and was responsible for field process during tool startup, demonstrations, presentations, field process support, development of hardware and software and integration of new Anti-Corrosion Module, manage improvement of vapor delivery system for production. Managed a number of engineering projects in response to field requirements. Coordinated testing and improvement of electrostatic chuck for use at cryogenic temperatures. Brought performance of vapor delivery system to production, handed off manufacturing engineering. Managed integration of Electrotech high pressure module into Renaissance platform including software, mechanical and electrical systems as well as detailed process characterization.

Metal Etch Process Manager 1/96 to 1/97
Plasma and Materials Technologies
Managed formation and growth of Metal Etch Development Group involving plasma etching. Responsible for customer demonstrations, development of Tungsten interconnect etch process. Support introduction of Al and Tungsten etch tools into production. Managed Al etch process development team having three dedicated engineers. Transferred Al etch process to new Pinnacle 8000R platform.

Member of Technical Staff 8/94 to 1/96
PMT, Research and Development

Developed Al etch process for PMT's MØRI helicon plasma source. Demonstrated superior Al to photoresist selectivity using $Cl_2/BCl_3/N_2$ etch processes on 6 and 8" wafers using Pinnacle 8000 cluster tool with MØRI helicon plasma source. Instrumental in sales to key customers in Korea (LGS, Hyundai) and Japan (Sharp). Improved data analysis software for Langmuir probe product. Demonstrated hydrogenation of poly-silicon TFT gates (Xerox). Studied strip and corrosion issues, LLS with Gary Selwyn

Postdoctoral Member of Technical Staff 3/93 to 8/94
Display Research Department — Dr. Richard A. Gottscho
AT&T Bell Laboratories, Murray Hill — Department Head

Studied low temperature silicon nitride deposition and subsequent processes for active matrix liquid crystal displays on plastic substrates. Used *in situ*, real time, attenuated total reflection Fourier transform infrared spectroscopy to study film and interface properties of SiN_x and other semiconductors. Studied aspect ratio dependent scaling of Si and GaAs trench etch rates in an ECR plasma reactor. Included etch inhibitor in ion-neutral synergy model to quantitatively describe data at different substrate temperatures. Supervised undergraduate summer intern.

Research Assistant 9/87 – 2/93
U.S. Dept. of Energy Magnetic Fusion Science Fellow 9/87 – 9/90
California Institute of Technology, Pasadena

Developed first plasma planar laser induced fluorescence diagnostic. Made first two-dimensional images of the plasma ion fluid velocity field. Found qualitative agreement between measured flow field of stochastically heated ions in a drift wave and calculations of the two-fluid drift approximation. Observed ion temperature oscillations coherent with the drift wave. Developed new theoretical viewpoint to study the effect of stochastic single particle dynamics on macroscopic plasma parameters.

Research Assistant Summer 1989
Los Alamos National Laboratory, NM

Wrote software for quantitative analysis of film images from soft x-ray pinhole camera on FRX-C/LSM field reversed configuration. Developed upgrade of x-ray camera to capture images directly with CCD camera for real time analysis of FRX plasma discharges. Collaborated with Dr. Dan Taggart under group leader Dr. R. E. Siemon.

Research Assistant 5/86 – 9/87
University of Wisconsin, Madison
Studied plasma wakes and double layers in Dr. Noah Hershkowitz's lab.

Freelance Programmer summers/vacations 4/82 – 6/85
Programmed math and science educational software for Control Data and Addison-Wesley

Teaching Experience

AT&T Mentor Program '93

AT&T Bell Laboratories
Taught semiconductor processing and ATR-FTIR to an undergraduate researcher while guiding her research project in our lab.

Summer Undergraduate Research Fellowship Supervisor '90 – '92
California Institute of Technology
Guided progress of three undergraduates during their research projects in our lab.

Teaching Assistant 9/91 – 6/92
California Institute of Technology
Lectured and graded homework for graduate plasma physics course.

Teacher 9/89 – 5/90
Caltech's Secondary Schools Science Project
Taught optics course to advanced high school students.

Technical Experience

Software — developed systems of programs for experimental control (custom and CAMAC), for data acquisition, analysis and display, for physical, dynamic and optical modeling, for digital image processing and for science education

Lasers — operated and maintained copper vapor, doubled Nd-YAG and dye lasers; built flashlamp pumped dye laser

Optics — designed novel low f/\# imaging system with multianode microchannel plate photomultiplier; set up and used variety of optical systems: x-ray pinhole camera, optical multichannel analyzer, spectrometer, scanning etalon, interferometer, CCD camera, photomultiplier, electro-optic modulator, photodiodes

Electronics — built TTL timing and control circuits, analog detection circuits, dc and gated high voltage circuits; maintained pulsed power systems

Other Skills — used and maintained UHV and standard vacuum systems; experienced with machine shop skills; proficient with $\TeX$, DesignCAD, Windows, Word, Origin, Excel, Project, Powerpoint

Honors

Lam Vista Award	7/04
Athletic Board Scholar (top GPA of all graduating varsity athletes at UW-Madison)	6/87
Trewartha Honors Undergraduate Research Grant	'86 – '87
Prof. Linnaeus Wayland Dowling Scholarship (math)	'85 – '87
Irma L. Newman Scholarship (math)	'85 – '86
Undergraduate Summer Institute (Livermore Natl. Lab., Hertz Fndtn., UC-Davis)	8/86

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A. D. Bailey III, R. A. Stern and P. M. Bellan, "Measurement of coherent drift-wave ion-fluid velocity field when ion dynamics are stochastic," Phys. Rev. Lett. **71**, 3123-3126 (1993).

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2. Method and apparatus for controlling the volume of a plasma – magnetic plasma screens, US6,322,661, Nov01.
3. Plasma processing systems – B field uniformity control, US6,341,574, Jan02.
4. Method and apparatus for producing uniform process rates – antenna and sandwich coupling window, US6,320,320, Nov02.
5. Antenna designs compensating for missing elements in real antennas, US6,518,705 Feb03.

6. Method and apparatus for producing uniform process rates – specific antenna design, US6,653,791, Nov03.
7. Method for quantifying uniformity patterns and including expert knowledge for tool development and control – multivariate uniformity metric, US6,723,574, Dec02.
8. A Method for Designing Antennas for Inductive Coupling Which Minimize Azimuthal Asymmetry, US6,744,213 May02.
9. System, method and apparatus for improved global dual-damascene planarization, US6,821,899 Nov04.
10. RF Plasma stability improvement, US6,838,832 Jan05.
11. Passive coils for plasma processing uniformity improvement, US6,842,147 Jan05.
12. Method for producing a semiconductor device - specific DCH antenna design US6,873,112, Mar05.
13. Method for quantifying Uniformity Patterns for Tool Development and Monitoring – Mass Analogy, US6,922,603, Jul05.
14. System, method and apparatus for improved global dual-damascene planarization (uniformity compensation focus), US6,939,796, Sept05.
15. Small Volume Plasma Process Chamber with Hot Inner Surfaces, US7,009,281, Mar06.
16. Plasma In-Situ Treatment of Chemically Amplified Resist, US7,022,611, Apr06.

Evidence Document 2

Docket No.: 2328-053 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	
Tuquiang NI et al.	:	Confirmation No. 5171
U.S. Patent Application No. 09/821,753	:	Group Art Unit: 1763
Filed: March 30, 2001	:	Examiner: Luz L. ALEJANDRO

For: PLASMA PROCESSING METHOD AND APPARATUS WITH CONTROL OF PLASMA EXCITATION POWER

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF ANDREW D. BAILEY III, Ph.D.

I, Andrew D. Bailey III, Ph.D., hereby declare as follows:

1. Exhibit 1, submitted with my Declaration filed in the U.S. Patent and Trademark Office on June 9, 2006, is an accurate statement of my education, work experience, honors, publications, presentations and abstracts and issued United States Patents. As part of my work experience, I have worked closely with those of ordinary skill in the art relating to plasma processing of workpieces and have supervised many persons of ordinary skill in the art in the plasma processing of workpieces. As a result of my work experience, I am knowledgeable of those of ordinary skill in the art in the plasma processing of workpieces. I am also regarded by my peers as an expert in the technology relating to plasma processing of workpieces. Many of the publications listed in Exhibit 1 are publications in refereed journals, and as such, were subject to peer review prior to publication.

2. I have carefully read the referenced application as filed, the claims I understand attorney for applicants plans to submit with this Declaration in the referenced application,

the Office Action of March 9, 2006, and the Bhardwaj et al. reference, USP 6,051,503, primarily relied on in the Office Action.

3. My review of the referenced application, as originally filed, finds support for the requirement of claims 46 and 58 for "the AC etchant plasma always being the dominant material applied to the workpiece while the desired shape is being formed."

(a) Page 5, lines 26-28 and claim 8, page 19 indicate that, in the preferred embodiment, a gas species is ionized into a plasma that etches the material and that the preprogrammed gradual power change and the species are such that the material is shaped so a rounded corner is formed in the material as a result of the etching. This statement enables one of ordinary skill in the art to understand that in one embodiment the desired shape is the rounded corner. One of ordinary skill in the art would understand from the statement that an AC etchant plasma is always the dominant material applied to the workpiece while the rounded corner is being formed. Otherwise, etching of the workpiece to obtain the rounded corner would not have occurred. One of ordinary skill would understand that if an etchant gas were not always dominant, e.g., if a passivation gas or a dilutant gas were dominant, the rounded corner of Fig. 6 could not have been formed.

(b) Page 16, line 23-page 17, line 2 states microprocessor 201 has a memory system that performs the final etch operation for 15 seconds. The final etch operation causes formation of a predetermined shape, e.g., a rounded edge 216 between point 212 and base 214. During the 15 second final etch operation a suitable mixture of HBr/O_2 constantly flows from source 68 into chamber 40 while the power that amplifier 132 supplies to electrode 56 gradually changes from 200 watts to 100 watts. One of ordinary skill in the art would interpret such a statement to mean that the etchant HBr is always dominant over the O_2 passivation gas during the 15 second etch operation. One of ordinary skill in the art knows that if the etchant gas HBr and the passivation gas O_2 both constantly flow to a chamber to perform an etch operation, that the etchant gas HBr must always be dominant over the passivation gas O_2 during that etching operation. Otherwise,

material in the passivation gas would be deposited on the workpiece and would have a greater effect on the material being worked than the etchant gas. As a result, the rounded corner, i.e., edge, illustrated in Fig. 6 would not have been formed.

4. I do not agree with the statement in the March 9, 2006, Office Action that Bhardwaj et al. discloses converting a gas species into an AC etchant plasma that is either the dominant material or the only material that is continuously applied to a workpiece while a feature of the workpiece is being formed.

(a) The specification and each of independent claims 1, 29, 30 and 31 of Bhardwaj et al. are concerned with a method of forming a feature in a semiconductor substrate. To form the feature, the substrate is subjected to a cyclical process including plural successive process cycles. Each of the successive process cycles includes a first process of reactive ion etching and a second process of depositing a passivation layer by chemical vapor deposition.

(b) Based on the foregoing, it is clear to me, as an expert in the technology, that Bhardwaj et al. does not disclose converting a gas species into an AC etchant plasma that is either the dominant or only material that is continuously applied to a workpiece while a desired shape in the workpiece is being formed. The entire thrust of the Bhardwaj et al. patent is to form a feature, e.g., a trench, by alternately etching and depositing materials, as indicated, for example, by the waveforms of Figure 7, wherein the first, fourth and seventh columns are associated with etching, the second and fifth columns are associated with deposition, and the third and sixth columns are associated with pump out of gases. Figure 7 indicates that during the etch steps, the coil power and the bias power remain constant and that the coil and bias power also remain constant during the deposition steps. The waveforms of Figure 9(i) and 9(ii) indicate bias power changes abruptly between the etch and deposition steps. The RF bias is high during the deposition steps when pressure is low, and is low during the etch steps, when pressure is high. Column 9, lines 47-51 indicates the bias changes from low to high as the cycle changes from deposition to etch, respectively, in synchronism with pressure changes from low to high. These alternate

etch and deposition steps occur during formation of a feature, particularly a trench wall, as discussed in column 1, lines 4-13 and as set forth in Bhardwaj et al.'s independent claims.

(c) The discussion in Bhardwaj et al., column 8, line 27-column 9, line 34 indicates the importance Bhardwaj et al. ascribed to the alternate etching and deposition steps to form a feature. This portion of Bhardwaj et al. indicates the problems associated with the prior art, as represented by Figure 3, in forming a silicon trench only by etching. The paragraph bridging columns 8 and 9 is particularly relevant because it discusses the importance of the passivation, i.e., deposition, step.

(d) Based on the foregoing, Bhardwaj et al. does not form a desired shape of a workpiece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the workpiece while the desired shape is being formed, wherein the amount of AC power applied to the plasma during etching of the workpiece to form the desired shape gradually changes and a gradual transition in the shape of the material in the workpiece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material. While Bhardwaj et al. discloses gradual power change, the gradual power change is always associated with alternate application of etchant gas and deposition gas to the workpiece during formation of the feature, e.g., a trench.

(e) In addition, Bhardwaj et al. does not form a desired shape of a workpiece by converting a gas species into an AC etchant plasma that is always the dominant material applied to the workpiece, wherein the amount of AC power applied to the plasma during etching of the workpiece to form the desired shape gradually changes and a gradual transition in the shape of the material in the workpiece being processed occurs in response to the gradual power change that occurs during the gradual transition in the shape of the material.

5. An unobviousness aspect of the present invention over Bhardwaj et al. is that desired shapes can be formed by gradually changing plasma power without changing the gas species in the plasma. In Bhardwaj et al., the species are repeatedly changed from an etchant gas to a passivation gas during formation of a desired shape, e.g., walls of a trench. The present application, on page 3, lines 3-28, indicates the advantages of maintaining species constant while a desired shape is being formed. By practicing the method of the present invention, the problems of the prior art that Bhardwaj et al. were trying to overcome are avoided. This is because a true rounded corner is initially formed to prevent formation of the notches of Fig. 13, as described in column 8, lines 27-43. In addition, the method of the present invention is more efficient, more effectively controlled and is simpler to execute than the Bhardwaj et al. process because there is no need to switch between passivation and etchant gases.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine, or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

DATED this 17 day of May, 2007, at 18:30 Fremont, CA

Andrew D. Bailey III, Ph.D.

Evidence Document 3

Docket No.: 2328-053 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:
Tuqiang NI *et al.*	: Confirmation No. 5171
U.S. Patent Application No. 09/821,753	: Group Art Unit: 1763
Filed: March 30, 2001	: Examiner: Alejandro Mulero, Luz L.

For: PLASMA PROCESSING METHOD AND APPARATUS WITH CONTROL OF PLASMA EXCITATION POWER

DECLARATION UNDER 37 CFR 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Thomas A. Kamp, hereby declare as follows:

[0001] In 2000, I earned, from San Jose State University, a Master of Science Degree (MSE) In Materials of Electronic Devices. My masters degree thesis was entitled "PECVD Undoped Silicon Glass Film in 300 Millimeter Wafers." In 1995, I earned, from San Jose State University, a Bachelor of Science Degree (BS) in Materials Science.

[0002] Between 1995 and 2000 I worked for Mattson Technologies on machines for manufacturing semiconductor equipment, particularly machines relating to deposition and stripping of materials on semiconductor wafers.

Between 2000 and the present time, I have been employed by Lam Research Corporation, the assignee of the referenced application, in connection with the development of machines for manufacturing semiconductor equipment, including aspects of such machines for forming features, such as trenches, vias, corners, contacts and lines, on semiconductor wafers. My current title is Senior Staff Process Engineer.

[0003] I am one of the patentees of the following four United States Patents:

7,186,661, entitled "Method to Improve Profile Control and N/P Loading in Dual Doped Gate Applications" (attached Exhibit 2);

7, 098, 141, entitled "Use of Silicon Containing Gas for CD and Profile Feature Enhancements of Gate and Shallow Trench Structures" (attached Exhibit 3);

6, 939, 811, entitled "Apparatus and Method for Controlling Edge Depth" (attached Exhibit 4); and

6, 921, 724, entitled "Variable Temperature Processes for Tunable Electrostatic Chuck" (attached Exhibit 5).

All of these patents are concerned, to at least a certain extent, with forming features, including trenches, in semiconductor wafers.

[0004] During my employment with Lam Research Corporation I have personal knowledge of rounded corners of trenches of workpieces, in the form of

silicon wafers, being formed in a vacuum plasma chamber. The rounded corners were formed by converting a gas species that was supplied to the chamber into an etchant plasma that was continuously applied to the workpiece while the rounded corners were being formed. While the rounded corners were being formed, the power applied to the etchant plasma was gradually changed. The gradual power change was such that the power did not remain constant for durations in excess of one second while the rounded corners were being formed. While the rounded corners were being formed, in first instances, the following parameters were maintained constant: (1) pressure in the chamber, (2) flow rate of the gas species into the chamber, and (3) species flowing into the chamber. While the rounded corners were being formed in second instances, plasma power was gradually changed as indicated above, and pressure in the chamber was gradually changed while the flow rate of the gas species into the chamber and the species flowing into the chamber were maintained constant. Microphotographs of the rounded corners thus formed in both the first and second instances indicated the rounded corners were smooth without any sign of damaged edges. The smooth rounded corners were formed in both the first and second instances without the necessity for a soft etch being applied after the corners were formed.

[0005] I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine, or imprisonment,

or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Dated this 9 day of May, 2007, at Fremont, California.

Thomas A. Kamp